Explanation modelling and competences management

Ioan Rosca [a]
[a] *Teleuniversity of Montreal, LICEF , Montreal, CANADA, ioan.rosca@licef.teluq.uqam.ca*

I have dedicated many years to the study of the explanation phenomenon- which stands to the base of instructional/ informational/ supporting processes- and which I have tried to understand, model and instrument. But the difficulties encountered in the unitary treatment of systems-in-process integrating objects, persons, knowledge and activities- proved to be redoubtable. I wished to contribute to the emergence of the science of explanation or to stimulate an interdisciplinary effort in this direction. I continued my researches in LICEF projects, which aimed the modelling/ instrumentation of instructional systems distributed on Internet, trying to value the potential for synaptic matching of the computer network. To allow the blend of emergent and orchestrated activities composing the physiology of knowledge (information) based systems I have relied on the indexation of all the elements relative to the same knowledge reference system. In the same time, watching the evolution of knowledge embodied in participants and represented in informational structures I proposed the declaration of the explicative qualities of the support documents and persons, using a specific ontology. These pedagogical competences (postures) can orientate the semantic equilibrium around the information/instruction operations- supporting advanced semantic services (matching, alerting etc.). Although interesting, these developments are still far from building a method for solving documentary equations such as "Find that system of explicative support tools that allows a user to accomplish a given competence increase". The theoretical foundation of such a problem space confronts us once more with the problem of modelling the explanation phenomenon.

Keywords: knowledge representation, competence, explanation, semantic matching, pedagogical indexation, transdiscplinary modelling

1 INTRODUCTION: BETWEEN KNOWLEDGE, COMPETENCES AND EXPLANATION

Beyond inevitable technical ambiguities [1], the passage from "information" management to "knowledge" propagation facilitation represents a shift of accent towards persons, as unique sense generators, carriers and consumers. Once this step made, we must go further, correlating the study of abstract concepts (theoretical entities represented in various languages and models) with that of living ones, which are born and evolve in a conscience. Knowledge described in documents, organised in domains usable as references and modified in activities- is embodied in persons, fulfilling its sense in the context of every person's destiny and experience. The complex and intimate relationship between a person and a concept can be approximated (explicitated) by various "competence" indicators [2]. Their evolution reflects, more ore less expressively, knowledge deepening.

Learning can occur diffusely, as an effect of life experience, or can be the result of dedicated activities. In the context of these explicative processes, the "learner" can receive the support of a human partner ("teacher") or can use pedagogical instruments previously conceived by an author. The complete physiology of the expert-novice explicative phenomenon, involving multiple dimensions (the logical-semantic, the communicational-pedagogic and that of the synchronous or asynchronous cooperation mechanics), is extremely difficult to model and automate. On the other hand, for exploiting a large space of assistance means, the computer network may be salutary, facilitating the matching between learners (users) and the accessible resources (persons or documents). To make such synaptic services possible, the explicative demand and offer must be previously declared, using certain formalisms, accessible to persons and to artificial intermediation agents. The choice of the adequate representations requires the profound understanding of the dialogical explicative process.

2 MODELLING EXPLANATION

2.1 Quest of modelling principles

I approached the study of educative cooperation in a double hypostasis: as a teacher- trying to understand the strategies of efficient didactics and as an engineer- trying to optimise the instruction's instrumentation. After many years of practice, meditation and lab experiences, I have reached the conclusion that the concept of explanation facilitates the fusion between "instruction" and "assistance" and that the foundation of the "instructive-productive procedures' management"- should be a unitary theory of explicative processes- including material and cognitive aspects.

In my PhD thesis [3], I tried to conceive a systemic model ([4], [5]) for the (instrumented) explanation

phenomena, one that would integrate the multitude of involved aspects (semantics of the explained subject, logic and rhetoric of the demonstration [6], representation sharing [7], physiology of co-action and of the communicational process [8], physiology of perception, understanding and memorisation, influence of the technology, motivational and economical levers etc) coagulating the observations extracted from a multitude of domains (psychology and cognitive sciences, communication and information sciences, semiotics and multimedia, logics and epistemology, sciences of education, computer telecommunications, theory of negotiation and decision, etc)- each having its own primitives, epistemology, language, paradigms, experience, rituals, models and priorities. This situation produces a dispersion of the observations and models, the secondary space of reflection becoming more complicated then the first-of the observed phenomenon. An integrative approach would be necessary, one that would remake the unity of the observation's target, coagulating a model image, beyond the disciplines' borders. But the program of the trandisciplinary movement [9] is not yet backed by an adequate epistemology and modelling methodology.

The problem complexity [10] forced me to resign myself to elaborate partial models (morphological and physiological), to structure a "map of my perplexity" and to enounce principles that have subsequently guided my research. From those, the must important is the observation that "explanation" is based on the cognitive consonance [11] lived by a human pair. Synchronous or asynchronous, sonorous, textual or graphical, direct or remote, realized through communication, resource sharing or co-operation, exploiting the physical interaction through objects and the innate or cultivated human communication capacities (language etc.)- the explicative relationship between an "expert" and a "novice" is essentially a bipolar phenomenon, based on the collaboration between two free-will centres [12] .

2.2 A simple model of the explicative process

Even if very simple, the starting model exposed in the thesis [3]– reproduced in figure 1- depicts the core sub-systems of the explicative pyramid. Their separate treatment is practically and analytically interesting, but must be done without neglecting the unity of the whole:

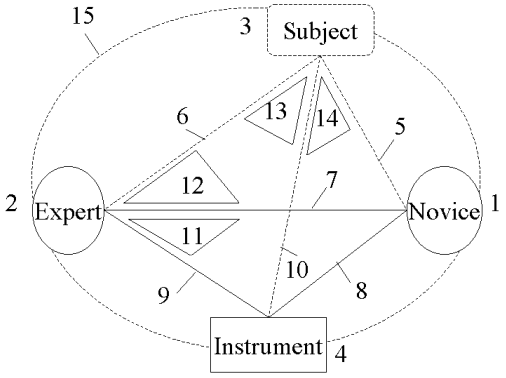

Fig. 1. The explanation basic model

1 **N**ovice (assisted, learner)- who ameliorates his competence on subject S, as a consequence of explanation
2 **E**xpert (assistant, teacher)- who participates, using his competence to explain (propagate) the subject S
3 **S**ubject (concept, knowledge)- abstract entity representing the live knowledge that must be propagated, represented (identified) by the denominating word or by coordinates relative to a semantic reference system
4 **I**nstrument (document, interface)- object carrying explicative messages, used in asynchronous explanation
5 Comprehension edge- sub-process of the development of N's competence on the subject S
6 Expertise edge- process of using the competence detained by E (for the orientation of explanation)
7 Dialogue edge- process of direct relation using the semantic consonance- that makes explanation possible
8 Use edge- groups the mechanics (physiology) of N's interaction with the explicative instrument
9 Construction edge- includes the mechanics of the actions for the conception of the instrument
10 Description (representation)- relationship between the message-carrying object and the subject it refers to
11 Direct Communication Side (presentation, dialogue)- E's direct influence on N's competence
12 Intermediated Communication Side- E's influencing by N, through message-objects
13 Exploration Side - learning by the use of the explicative instrument
14 Composition Side - operation of "loading" the instrument with explicative message (potential)
15 The complete explicative pyramid - supposes the modification of E's competence on a subject S as a result of a partner N's intervention- directly or intermediated by message-carrying instruments I.

3 PREPARING EXPLANATION THROUGH COMPETENCE MATCHING

3.1 A chain of projects

To improve the model exposed above, I have used a hybrid methodology, combining meditation on my own experience (the "introscopic" approach), with various theoretical and experimental studies, made over the years in a series of projects.

The main goal of the experiments performed, between 1994 and 1996, within the GRAEMI and HERON multimedia labs framework was the study of explicative messages composition and of their perception processes (exploration, comprehension)- forming the asynchronous communication chain. Noting the "learning environments'" aspirations towards "interactivity" and "adaptability", I have also approached the problem of facilitating co-operation (central to explanation by co-execution), in the "Metamorphic multimedia" and "Meta-demonstration" projects. In the theoretical model of computer-assisted demonstration [3], I have joined, in the "explicative mode", the elements determining the cooperation's physiology (communication channels and forms, floor control rules, resource sharing and initiative negotiation protocols) - separating them from explanation semantics. In the "Triple controlled explanation" project, inspiring myself from the literature on the "awareness" in "shared windows", I have tested various stratagems for communicating the demonstrative gestures and I have studied the expert-computer-novice triangulation. Having great doubts about the automation of the explicative act and noticing that the SAFARI project (in which I had involved myself to deepen the issue of managing initiative between human and artificial agents) was aiming at equipping computers with teachers more than equipping teachers with computers, I have delimitated myself from this orientation [13], quitting the research of pedagogical artificial intelligence to explore the computer's potential as human assistant in the intelligent management of explicative processes.

Explicative cooperation can consist of sharing documentary resources (and, implicitly, the meanings that these documents clarify). The organization of the information (knowledge) bases is an approach complementary to the discursive act. A knowledge structure has an explicative potential that each exploration materializes. Information search is an interrogative discourse, alternating with lecture stages, to compose an exploration phenomenon. I have approached, between 1996 and 1999, in the TaxiNet and other WEB projects, the problems of organizing documentary systems, studying the indexation and reference processes and the physiology of information transactions through the Internet. The TaxiNet "dispatchers" would have facilitated immediate or programmed connection between Internet guides and their clients, based of various mechanisms for treating (matching) support requests and offers. Afterwards, they would have sustained cooperative navigation sessions, or chains of asynchronous documentary cooperation.

I continued these researches in LICEF projects, which aimed the modelling/ instrumentation of instructional systems distributed on the Internet: EXPLORA (a virtual campus management platform [14], MOT+ (a knowledge structure, pedagogical scenario and resource conception/diffusion editor [15], ADISA (Distributed Workbench for Learning Systems Engineering [16]), SavoirNet (the transition of EXPLORA towards a service provider position) EDUSOURCE (inter-operation system for pedagogical resource repositories based on metadata records), GEFO [17] (a cooperative pedagogical workflow manager based on the common indexation of persons, documents and activities [18]), LORNET [19] (aiming the construction of TELOS middleware- an infrastructure for technical and semantic inter-operation between educational service sources and resources repositories).

3.2 Services for optimising the competence equilibrium

I have defined TELOS' conceptual architecture so that it sustains the modelling and the management of distributed instruction activities: from the emergent ones (searching human and material support resources and freely chaining operations) to the orchestrated ones (through rigid or adaptable scenarios, used in the enactment of the represented procedures [20]). Among the aggregation types instrumented in the system, an important place is held by the semantic aggregation [21]. Further on, I summarise the knowledge management flux, standing at the grounds of the optimisation services for the explicative competence equilibrium- tested with the GEFO prototype.

Knowledge, language, representation in domains, coordinates. We represent live knowledge in symbolic structures allowing us to refer to. Based on the language's natural reference system, knowledge domains (spaces) can be built and be used as "knowledge reference systems". The qualities of the indexing and retrieval processes based on them depend on their organization. Even pointing towards a thesaurus or a text collection – can be useful. A "classification" (taxonomy, catalogue, tree) facilitates the orientation and the "inheritance" of the attributes eventually connected to nodes (competences, etc.) Relational databases (or

XML)– define structural significations. "Dictionary" type organization accelerates the searching of terms. Hypertextual structures favour navigation. Declarative languages valorise their recursive possibilities in sustaining inferences. Notional graph modelling techniques as MOT [15] introduce typed links (composition, precedence, etc)- suggestive for humans and useful for mechanical deductions. The best potential of automatic inference (assistance) is obtained when the reference system is organized according to a "computer-comprehensible" logic – hence the interest for "ontologies" [22].

Competences of persons: mastering levels, abilities. The pertinent choice of a support person requires the prior declaration- in his record's fields- of information witch can influence the decision (negotiation) of its implication. Furthermore, in a support (instruction) system, the evolution of the subjects' understanding and the contributions to this evolution must be observed. We can use "competences" C (qualitative and quantitative descriptions of someone's position relative to knowledge): "mastering levels"- measured on a scale M or "abilities" (knowledge/ comprehension/ application / analysis/ synthesis / evaluation) [23]. But the task to calculate a global competence for K starting from the competences for concepts decomposing K… is not obvious. The difficulties led to simplifications as the (discussible) use of uniform evaluation scales like: 0/1, 0-10, 0-100, A-F - instead of a fine-grained competence management.

Learning. Educative processes as competence operators. For each subject, the learning (comprehension) process can be expressed by the continuous evolution of his competence c(t). A person's participation in a given educative activity will thus be materialised with (c1,c2) competence increases- for each explained concept. However, it is not certain that another person, exposed to the same activity, will perform the same increase. An activity planned in a pedagogical scenario can aim a progress (C1 - supposed level, C2 - aimed level) but it remains a probabilistic "competence operator"- a real participant passing from a level c1 to c2- even when all the requirements are met.

Pedagogical competences (postures). The simplistic presumption that a person E mastering a subject at a level x can support the increase from 0 to x of the competence of any supported learner N in a given explicative operation O- can easily be contradicted by facts. The success of the E-O-N relationship depends on many parameters (the experience of practicing the operation O as a didactic tool for explaining the subject, the affinities between E and N etc). The contribution of E, in each case, and for each sub-concept, is difficult to evaluate. Despite all these difficulties, the assistance, matching, selection and recommendation services still need quantitative indicators, even imperfect. In order to observe the competence equilibrium around pedagogical operations, I have organised the competences space of a person P on "postures": (knowK, aimK, explainK(x,y), describeK(x,y), recommendK(x,y), evaluateK(x,y))- where the parenthesis show a predicate depending on the detained (x) or aimed (y) "mastering level" of the person to which P could explain (transmit by a document, evaluate, recommend etc) the knowledge k.

Document indexation. To facilitate the retrieval, the characterization record of each documentary resource contains, besides the general fields (identifier, author, address, size, version, publishing date etc) some data referencing (indexing) the content. But the "knowledge references" that we usually meet are, more or less equivocal: do they signal that the document presumes them from the user or can explain them to him?; that a document defines that particular knowledge, explains it, applies it in problems that deepen its comprehension, uses it in the clarification of other concepts- or only contains a word that represents it? The use of knowledge in the place of competences may also hide a binary approach (knows / does not know)- reductionism eluding the gradual character of "learning". Therefore, the indexation of explicative documents poses similar problems to that of referencing support persons. They can be partially considered the author's representative towards the expected user (minus the interactivity limitations). That is why I have also characterises their explicative potential by (c1,c2) increases.

Matching for the emergent mode. 1 The participants having this right (mandate) add new resources to the appropriate repositories and declare their explicative capabilities 2 The resource users exploit the retrieval instruments (based on the link between the language of the requests and the knowledge reference spaces employed for semantic and pedagogical indexation). 3 Operations are chained freely, according to the users' necessities. 4 As a result of using some resources, data (traces or annotations) can appear. This information constitutes suggestions for refining and correcting references or even the reference system.

Matching for the orchestrating mode. The generic actors A (and generic instruments I) appearing in the operations' models have c(a/i,k) competence characterizations, analogue to those of the real participants P (or documentary resources R) that will concretise them- allowing the action of selection criteria as c(p/r,k)>=c(a/i,k). We can optimise (assist) the selections (persons and connected documents) operated in any phase of the concretisation chain, providing mechanisms for the surveillance of each operation's internal competence equilibrium. For example (see [24]) for an operation requiring a competence level O, approached by a learner having a competence c, supported by a an assistant capable to sustain c1- c2

increases and by a document capable to sustain c3- c4 evolutions, we can observe situations as: (c1<=c<O<=c2 or c3<=c<O<=c4)- any support component is sufficient, or (c1<c<c3<c2<O<=c4) - the assistant can lead the executor in the document's efficiency range. "Semantic services" may be realized by optimisation agents, supporting the selection, launching useful alerts, automatically matching etc.

4 REFINING COMPETENCE MANAGEMENT AND REMODELING EXPLANATION

The organisation formulas and the services experimented in GEFO use simplifications, admissible (fructuous) in certain applicative contexts. But they only represent the beginning of an ample and predictably difficult research on the management of competences and of processes modifying them. As Wittgenstein has signalled, any concept is a phenomenological web that can't be concentrated in a term, or identifiable as a node in reference domains. The description of someone's evolving knowledge can be explicited only in some measure. The estimation of the mastering increase, using a one-dimensional scale- is coarse. The decomposition in sub-knowledge can continue, recursively, exponentially. Pedagogical expertise does not reduce to a supposed/aimed level pair. Explicative matching would have to consider the affinities between the expert's (document's author) explicative style and the beneficiary's learning style.

The path to a scientific methodology for solving various types of "explicative equations" (selecting the optimal tools to support a certain competence evolution, in a given availability space) faces major theoretical obstacles. Apart the complexity and plasticity of systems involving knowledge, we are confronted to genuine ambiguities of primitive concepts and with inevitable vicious circles (explaining explanation, concept of concept, etc). Perfecting (pedagogical) competence modelling and refining their management, in the context of the "pragmatic web" orientations [26] brings me back to the problem of modelling the explanation process

REFERENCES

[1] Kaipa P. Knowledge architecture for the twenty-first century. Behaviour & information technology, vol. 19,no3, pp153-161, 2000

[2] Phelps R. Hase S, Ellis A., Competency, capability, complexity and computers: exploring a new model for conceptualising end-user computer education, British Journal of Educational Technology, Vol36, no1, 67-84,2005

[3] Rosca, I. Towards a systemic vision of the explanation process; the story of a research on integrating pedagogy, engineering and modelling- PhD thesis, http://www.ioanrosca.com/educatie/these, 1999

[4] Andreewsky, E., Systemique & Cognition, Dunod, Paris, 1991.

[5] Rosca, I, Morin,A A system vision about explanation in education Actes Colloque du Cipte, Congrès Acfas, 2000

[6] Gilbert J & others. Models in explanations, INT J. SCI EDuc., vol 20, No1-2, pp 83-97 and 187-203,1998

[7] Zhang J., Norman D.: Representation in distributed cognitive tasks, Cognitive science, 18, 87-122 (1994)

[8] Wilmot, W.W. (1987). Dyadic communication (3rd Ed.). NY: Random House.

[9] Nicolescu,B. La transdisciplinarité - Manifeste, Éditions du Rocher, Col. "Transdisciplinarité", Monaco, 1996

[10] Morin E., Introduction à la pensée complexe, ESF Éditeur, Paris, 1990

[11] Odobleja S., Psychologie consonantiste. Librairie Maloine, Paris (1939), second edition E. S.E Bucuresti (1979)

[12] Dalal, N. P., The design of joint cognitive systems: the effect of cognitive coupling on performance, Int. J. Human-Computer Studies, 40, 677-702, 1994.

[13] Rosca I, A. Morin, May we rediscover the dialog between teacher and learner in the processes of computer based instruction?, Acfas congress, Montreal,(1996)

[14] Rosca, I., Paquette, G.. The Explora2 system, Congrès TeleLearning, Vancouver , 2001

[15] Paquette,G., Rosca,I. Modelling the delivery physiology of distributed learning systems. Technology, Instruction, Cognition and Learning (TICL) ,v1, No2, 2003

[16] Paquette, G., Rosca, I., De la Teja,I. & oth. Web-based Support for the Instructional Engineering of E-learning Systems, Proceedings of WebNet'2001, Orlando FL, October, W. Fowler, J. Hasebrook (eds.) pp. 981-987, 2001

[17] Rosca, I., Rosca V. Pedagogical workflow management with functions, LOR'04 congress, Montreal, http://www.lornet.org/i2lor/pps/Rosca.pps, 2004

[18] Paquette,G. Rosca; I An Ontology-based Referencing of Actors, Operations and Resources in eLearning Systems SW-EL, 2004

[19] Rosca, I., Paquette, G., Mihaila, S., Masmoudi, A. "TELOS, a service-oriented framework to support learning and knowledge Management" E-Learning Networked Environments and Architectures: a Knowledge Processing Perspective, S. Pierre (Ed), Springer - in press, 2006

[20] Vantroys T, Peter Y: Cow, a flexible platform for the enactment of learning scenarios, CRIWG Proceedings, Autrans, France, 2003, Springer Verlag

[21] Rosca, I., Paquette, G.: Organic Aggregation of Knowledge Objects in Educational Systems, Canadian Journal of Learning Technologies, Volume 28-3, pp. 11-26 (2002)

[22] Mizoguchi, R. 1 Introduction to Ontological Engineering. 21, pp. 365–384, 2003 2. Ontology development, tools and languages. 22, pp. 61-96,2004 In New Generation Computing,. Ohmsha Ltd and Springer Verlag
[23] Bloom, B.S. (Ed.): Taxonomy of Educational Objectives, the Classification of Educational Goals, Cognitive Domain, New York: David McKay Company Inc., (1956)
[24] Rosca, I. Knowledge management instrumentation for a community of practice on the semantic Web, Symposium REF-2005, Montpellier, 2005
[25] Murray, T. (1996a). Special Purpose Ontologies and the Representation of Pedagogical Knowledge. Proceedings of the International Conference on the Learning Sciences, 1996. AACE, Charlottesville, VA.
[26] De Moor A., Patterns for the pragmatic Web, 13th Int. Conference on Conceptual Structures, http://www.starlab.vub.ac.be/staff/ademoor/papers/iccs05_demoor.pdf, 2005
Note: The extensive reference list, determining the overflow of the 5 pages, may be easily shortened, if necessary.